DRAFT for Review

"Counterintuitive Ways Of Doing More With Less" –

A System Dynamics Contribution To The Urban Water Crisis In Developing Countries

Abstract

In urban areas across the developing world, access to water, particularly for drinking and other domestic uses, has now become a critical issue. Indian cities, perhaps as well as any, exemplify the social, environmental, economic and political problems that arise when this essential, life-supporting resource becomes scarce or unaffordable. The most common way of rationing water demand in India is to limit the supply to a few hours a day; during the remaining time no water flows through the distribution system. This model will attempt to show that the existing "intermittent" system does more harm than good, whereas a continuously pressurized 24x7 water system, with proper metering and pricing, ensures equitable and reliable distribution, without the need of additional supply and has positive socio-economic impacts that are system wide.

In urban areas across the developing world, access to water, particularly for drinking and other domestic uses, has now become a critical issue. Indian cities, perhaps as well as any, exemplify the social, environmental, economic and political problems that arise when this essential, life-supporting resource becomes scarce or unaffordable. With rising populations and growing economies, this problem can only get worse, and worse it is now getting – exponentially. Only careful, systemic analytical methods can help provide viable and sustainable solutions to this looming, potentially explosive crisis.

Conventional policies and practices have largely tried to address this issue by promoting ways to augment the supply of water. This has led to various proposals for fanciful and often grandiose technological fixes such as interlinking river basins, building large dams, desalination and intensified pumping from groundwater aquifers, many of which contain fossil water that is replenished only on geological time scales. Given the finite nature of this resource, these can at best be a strategy of limited, short-term value and at worst they could lead to unsustainable uses and inexorable destruction of what could have been a permanently renewable resource.

This study focuses on the possibilities of introducing technical, economic and institutional changes that can bring about solutions that viably reduce demand and provide equitable distribution across communities and economic strata.

320 million (30%) of India's people live in cities, a number that is expected to grow to 600 million (50%) by 2020.[1] Of these, some 60% live in slums under conditions of abject poverty, many of them on less than two dollars a day. With water and sewage systems designed for a far smaller population, these cities are already incapable of meeting the minimum water needs of their citizens, let alone being prepared for the rapid doubling of population they will undergo during the coming decade. Compounding the stresses of this growing gap between overall supply and demand are the high losses from leakage in the aging water mains (upto 70% losses in some cities), the contamination from sewage pipes that often run parallel to the water pipes and the rapid depletion of sources inside and outside the city from which it gets its water. In terms of equity, the situation is even worse: field studies show that in most cities, high-income groups, which comprise 20% of the population, appropriate 80% of the available supply[2].

To address the growing gap between demand and supply, cities in India, and indeed throughout South Asia, have chosen to ration the supply of water to urban households by making it available for only a few hours each day. More than 300 million urban dwellers of India suffer daily from this affliction of "intermittent" water supply. Depending on the region and season, piped water is supplied for periods ranging from 4 to 5 hours twice daily in some cities to one hour or so every 7 to 10 days in others. A typical city household might get something like two hours of supply every 2 days.

Higher income groups are able to cope with the demand-supply shortfall by installing large storage tanks, digging their own bore wells to tap into local aquifers or purchasing water from private supply tankers. Added to these coping costs are others at the household level, which include installing and maintaining pumps and purification devices - all of which require energy. It is estimated that coping costs, including amortized capital investments, range from USD 100 – 300 per household annually. In an average city, the author estimates that the total private investment made by households to overcome the limitations of intermittent supply is substantially greater than the entire public investment made in water-related infrastructure.

For the poor the situation is rather worse. The World Bank estimated that the poor in an Indian city slum pay over 400 times what the rich pay per litre of water[3]. Water supply to slums and other poor sections of cities is even more unpredictable than in the more affluent areas; women and young children have to wait for hours (sometimes days) on end for water tankers or public stand posts to bring water to their communities. This results not only in significant coping costs but also massive opportunity costs arising from not being able to work or go to school and lack of community cohesion as households fight for access to water. Furthermore, as the quality of the water provided through the intermittent system,

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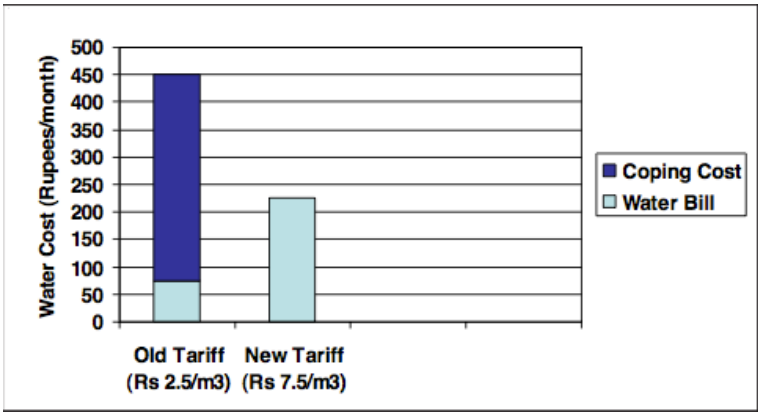
[1] http://www.rainwaterharvesting.org/crisis/Urbanwater-scenario.htm

[2] *www.wsp.org/wsp/sites/wsp.org/files/.../WSP_Karnataka-**water**-supply.pdf*

[3] Accounting for all opportunity costs – Dr. David Foster, "Water Works", Administrative Staff College of India

or private tankers in Indian cities is extremely poor, the external costs to individuals and the State in terms of dealing with water-borne diseases are extremely high[4].



Calculations by the Asian Development Bank in 2005, regarding the average monthly coping costs (USD 1 ~ Rs 50) to a household for intermittent water supply in India. The "New tariff" corresponds with the 24x7 system.

For most municipal water utilities in India, the costs of running an intermittent system are about twice as high as the revenues generated by the supply of water; a large portion (around 70% according to most estimates[5]) is lost due to leaks and theft; costs of operation and maintenance are prohibitively high because of corrosion, scaling and damage; and revenues are greatly reduced because of poor metering, billing and collection facilities[6].

(Picture Courtesy Dr. David Foster): poor women waiting to collect water from a private water tanker.

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[4] http://www.who.int/bulletin/volumes/88/7/09-066050/en/

[5] Asian Development Bank Report, "Helping India Achieve 24x7 Water Supply Service by 2010", K.E Seetharam, Geoffrey Bridges, 2005

[6] http://www.delhi.gov.in/wps/wcm/connect/DoIT_Planning/planning/economic+survey+of+dehli/content/water+supply+and+sanitation

The overall costs of intermittent water supplies can be very high; they (like any urban water supply) can best be analyzed under four categories:

- Operational costs (for what is actually supplied)
- Coping costs (for meeting the unmet portion of the demand)
- Opportunity costs (for activities foregone in acquiring needed water)
- External costs (for other costs arising from inadequate water quality or quantity, such as treatment of illness, loss of work or study time, loss of social cohesion, etc)

In most developed countries, the operational costs dominate, with the other three together accounting for a very minor fraction. This is because water is provided on a continuous basis, "24x7" which largely removes the need to supplement the water supplied by the municipality, and rarely causes health effects or other impacts that need to be mitigated.

In an Indian city, however, each of the four types of costs is non-trivial -- indeed it is significant. This is primarily because the water is supplied not only in inadequate quantity but also intermittently, which causes a substantial drop also in quality.

The salient features of a well-designed 24x7 system for an Indian city would be:

- Strictly NO interruption of water supply
- Continuous pressure in water mains
    - Should deliver water up to, say at least 10 meters
- Efficient distribution systems with losses less than 20%
    - Proactive maintenance and leak detection
- A Meter for every connection
    - An effective billing and collection system
- Block tariff (IBT) pricing schedules
    - A basic lifeline amount (say, 100 litres per capita per day) free for poorer households

With such a system, the chances of sewage and toxins seeping into water pipes are greatly reduced over intermittent supply systems and efficiency of water delivery is greatly enhanced.

As a result the poor benefit greatly: infant and child mortality rates drop drastically, water-borne diseases can be more or less eliminated and the daily battle for the bucket of water is a thing of the past.

The more affluent get considerable savings from elimination of the need for storage tanks, pumps and point-of-consumption filters, as drinking quality water is available on demand.

In India the “24x7” system was first proposed over a decade ago, but failed to have a serious impact on urban policy due to opposition from citizens and civil society organizations about the pricing and possible privatization of water and their perceived impacts on equitable, universal service delivery.

Common objections raised by opponents are that for a 24x7 system:

- The water resources available are not sufficient to meet the demand “even for (rationed) intermittent supply”
- Capital costs for leak-proofing, retrofitting and metering are too high
- The poor should not be charged for essential commodities
- 24x7 needs a public-private partnership, to raise the large capital needed and to provide the highly technical operational and support services
- Privatization of water is exploitative and will hurt the poor

Pilot projects over the past five years have demonstrated that many of the objections raised have been wrong or are based on assumptions that are not necessarily correct; intermittent systems, though well intentioned, do more harm than good.

Certain counterintuitive aspects of providing 24x7 are important and interesting:

- Metering and pricing households using a block tariff system (within which a basic lifeline amount is given free, particularly to the low income groups) ensures equitable distribution of water across a society
- To provide continuous water, more water supplies are not necessary; provided management is good, 24x7 systems on average reduce transmission and distribution losses by upto 70% as compared with intermittent systems.

Furthermore, case studies have shown that significant social transformations have taken place, particularly in poorer communities, with the introduction of 24x7 continuous water supply, as reductions in coping and in health-related and other opportunity or external costs have allowed the poor to significantly increase income and willingness to pay for social services provided by governments, civil organizations[7].

Unfortunately, in India, as in many other developing countries, neither governments, nor private sector utilities, nor civil society organizations have been

[7] On a field trip to a slum in Navi Mumbai, recently fitted with 24x7, a local resident told the author that since the introduction of the system, community problems have reduced and people are willing to consider paying for other welfare programmes such as sanitation services. Furthermore, slum residents no longer fight for water, thefts have gone down drastically (in the past, people used to leave their houses en masse when a water tanker arrived), more importantly, young men and women are able to go to work and even work over time, children are able to attend school more regularly.

able to share meaningfully their concerns regarding the costs and benefits of the 24x7 system.

Visits to several 24x7 project sites in India and following discussions with many stakeholders involved, it has become apparent that though there is plenty of empirical evidence that proves that 24x7 is a viable and useful system, there is considerable resistance on the part of municipal authorities to introduce such a system and on the part of the public to pay the costs, which they perceive to be higher than the status quo. The primary problem, to which System Dynamics may well provide the most effective solution is that the perceptions are based on inadequate knowledge, the data is often scattered and there is no effective, unified platform from which stakeholders with differing viewpoints can meaningfully interact and generate mutually acceptable ways forward.

The Purpose of The EarthSafe 24x7 model is to:

- Understand physical processes driving demand, distribution and supply
- Identify leverage points and potential pitfalls, “win-win” policy strategies
- Improve stakeholder participation, synthesize different forms of analysis
- Create a theory from differing mental models on the nature of “24x7”
- Bring about a change in perceptions, practices and policies

MODEL DESCRIPTION AND RESULTS

The model presented here is in an early stage of a long process of development; its purpose is to improve understanding of the broad structures related to supply, demand and distribution that simulate the behavior observed in existing 24x7 projects in India. More important, given the scarcity of data available, this model can help stakeholders identify the missing information and design research projects to acquire it. Furthermore, since the outcomes of this model can have a deep positive impact on the day-to-day lives of literally hundreds of millions of people, it sets out to shape a basic theory of 24x7 systems, which can be elaborated and amplified through further research initiatives that can lead to effective packages for communication with policy makers, practitioners and the public, and for constructive negotiations among diverse stakeholders.

This model attempts to provide an analytical framework for the 24x7 initiative undertaken by the city of Navi Mumbai – a new township and suburb of Mumbai (a major world mega city). Navi Mumbai was chosen, because it is one of the few cities for which 24x7 water was made part of the city's Master Plan, data is available and reasonably transparent and there is an excellent spirit of cooperation from engineers, managers, residents and civil society organizations about various processes. This analysis will focus initially on domestic consumption. Since industrial and agricultural uses are important, these structures will be added in future revisions of the model.

A detailed list of Initial Conditions,
VENSIM Model Equations, System Diagrams and supporting documents may be downloaded at:

http://earthsafe.in/247.zip

Table 1: A brief summary of the initial conditions[8]:

Basic Information			
WATER DEMAND	**HIG**	**LIG**	
Consumption UNMETERED	330	110	(LITRES/PERSON/DAY: LPCD)
Consumption METERED INTERMITTENT	240	80	LPCD
Consumption METERED 24x7	128	71	LPCD
Long term demand elastcity of price	-0.5	-0.1	
DEMOGRAPHICS			
TOTAL POPULATION	2,500,000		People
Base Population	1,250,000	1,250,000	People
Fraction of Total Population in:	*0.5*	*0.5*	
Net Growth Rate	*110%*	*160%*	
Assuming good management, fraction of households getting 24x7 connection each year	*20%*	*20%*	
Initial Fraction of new households entering city getting 24/7	*55%*	*55%*	
Price per litre intermittent	*0.002*	*0.002*	*Rs/Litre*
Price per litre24x7	*0.007*	*0.007*	*Rs/Litre*
AVERAGE SIZE OF HOUSEHOLDS	*4*	*5*	*people/household*
INITIAL # Households UNMETERED	*125000*	*200000*	*households*
INITIAL # Households METERED	*187500*	*50000*	*households*
INITIAL # Households METERED 24x7	*0*	*0*	*households*
Fraction of new households getting Metered Connections	*0.60*	*0.20*	
Fraction of water lost during Transmission and Distribution Intermittent System	*70%*	*70%*	
Fraction of water lost during Transmission and Distribution 24x7 System	*25%*	*25%*	

8 (1 USD ~ Rs 50)

The Demand and Distribution Sub-System

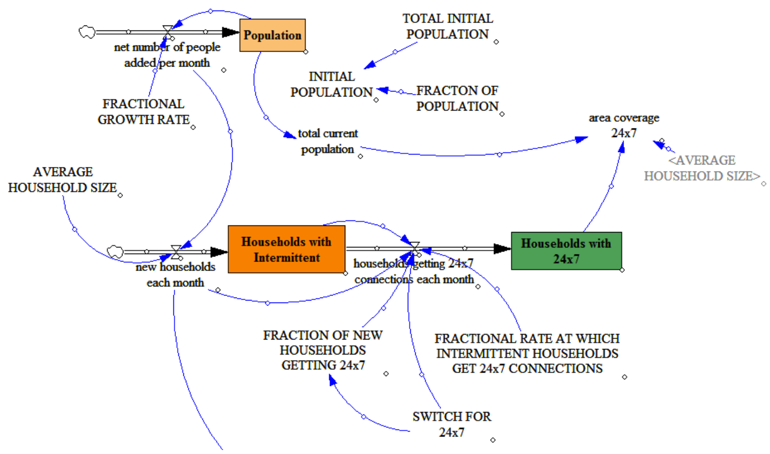

Figure 1. Flow of Households from Intermittent to 24x7

The basic structure governing the demand[9] and distribution aspect of the model is the flow of households (or connections) from the stock of Households with Intermittent Water Supply ("Intermittent") to Households with 24x7 Continuous Water Supply ("24x7") as shown in the graph above. Indian cities, and most areas within them, comprise a mixture of income groups. High income groups (HIG) usually co-exist with low income groups (LIG) that provide them with basic functions and services. The model disaggregates the behavior of the city's population by analyzing each group separately.

In Navi Mumbai, the number of households fitted with 24x7 supply has been growing at 20% per year, with the number of households having Intermittent connections showing a corresponding rate of decline. Furthermore, it is assumed that 60%[10] of new households coming up within the city boundary will have 24x7 connections from the beginning, and full coverage of all new households will be achieved within 5 years.

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[9] The literature often confuses demand with supply; in this model, demand is defined as the per capita consumption when supply is not limited.

10 Navi Mumbai's 24x7 project, which was started in 2007, is expected to have full coverage by 2012. Thus, it is assumed that the average yearly growth is 20%, which adequately represents the Municipal agency's capacity expansion trajectory.

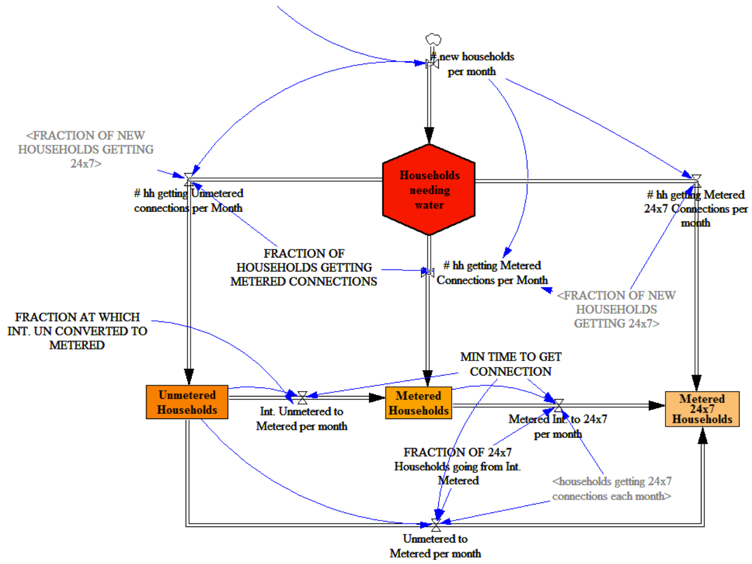

Figure 2. Types of Connections within the Distribution System

Addressing the issues of equity (universal access to water), pricing and demand, needs a good understanding of the physical nature of the distribution system. In Indian cities, people, rich or poor, generally get their water from piped connections provided the municipality, from private bore-wells which extract ground water directly, or from private contractors who generally deliver by truck. For the HIG, with individual houses or apartments, the piped connection comes directly into the dwelling unit. For the LIG, the pipe brings water to a neighbourhood and ends in a public stand post (sometimes Metered) from which local people can draw the water whenever it is available.

This model simulates the quantity and quality of water provided by piped connections to both high and low income groups and attempts to analyze the alternative arrangements by which an optimal distribution of the water resource can be achieved. Broadly speaking, there are three categories - Unmetered, Metered (both of which have intermittent water supply), and as the case of Navi Mumbai, Metered 24x7. Unmetered connections, which constitute high proportions in both income groups, usually take water directly from municipal water mains, and do not pay for their consumption (average per capita demand schedules can be seen in the table above)[11]. Depending on the number of households being given meters and 24x7 connections by the Municipality each month, Intermittent households gradually travel across to the stock Metered 24x7 connections. We assume a fairly mixed distribution of households in each category: for example, when 100 households are selected for 24x7 connectivity, 50 will come from the Unmetered stock and another 50 from the Metered Intermittent.

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11 Furthermore, intermittent piped connections lose over 70% of their water content during transmission, whereas 24x7 projects have demonstrated that losses can be brought down to less than 20%.

Each of the three categories of households, has a different demand behaviour; as seen from the table above, Unmetered households usually consume (and waste) a considerable quantity of water, whereas Metered Intermittent connections consume less and Metered 24x7 connections consume even less than that. Research shows that in the long-term, HIG demand for water is quite elastic; a value of -0.5 gave the best fit to the data[12]. The long-term price elasticity of LIG demand has been found empirically to be relatively low[13]; a value of -0.1 fits the data.

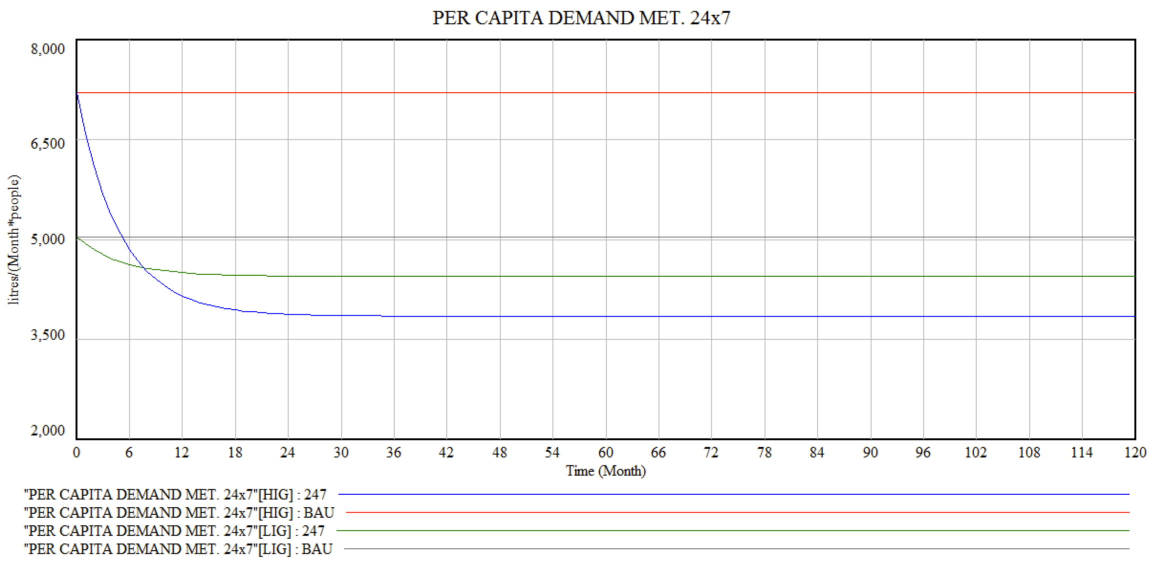

Figure 3. In the 24x7 scenario, HIG demand drops from 240 lpcd to around 140 lpcd over the course of the model run, though there is a slight reduction in demand in the LIG case, it is relatively inelastic to price changes.

The elasticity of demand is important from an equity and environmental point of view; if price signals are accurate then households will tend to consume less, regardless of income group. To put things in perspective, the conventional price consumers pay in most cities averages around Rs 0.002/litre, which for HIG Intermittent Metered users, comes to Rs 60/month (approximately US$ 1.30). The cost to most municipalities of processing and supplying water is at least five times as much[14]. For political and other reasons, State and local governments have long chosen to subsidize the price of water, despite the massive losses incurred.

The model assumes a different tariff system for 24x7 systems. The basic price of water is raised substantially, to Rs 0.007/litre. A basic "lifeline" of 100

12 The demand elasticity of price formulation found in Business Dynamics (Sterman, 2002) was used to calculate the change in demand: Demand = Reference Demand*(New Price/Ref Price)^elasticity. A study on the short, medium and long term demand elasticity of water for high income groups can be found at: http://www.hks.harvard.edu/fs/rstavins/Monographs_&_Reports/Pioneer_Olmstead_Stavins_Water.pdf

13 http://siteresources.worldbank.org/INTWAT/Resources/4602114-1203716020124/Discussion_Paper_5.pdf

14 http://articles.timesofindia.indiatimes.com/2009-12-02/delhi/28070851_1_djb-water-usage-sewer-maintenance-charges

litres/person/day is provided free to all LIG households; beyond that, all users, LIG or HIG, are charged Rs 0.007/litre. The "lifeline" threshold, below which the price is zero, is basically a block tariff system, which obviously reduces revenues collected from the low-income group for the municipality. However, overall the 24x7 price charged to HIG and beyond the lifeline threshold to LIG acts to substantially increase overall revenue collection. Revenues could be further raised by cross subsidizing with revenues from industrial users who could be charged even higher water tariffs.

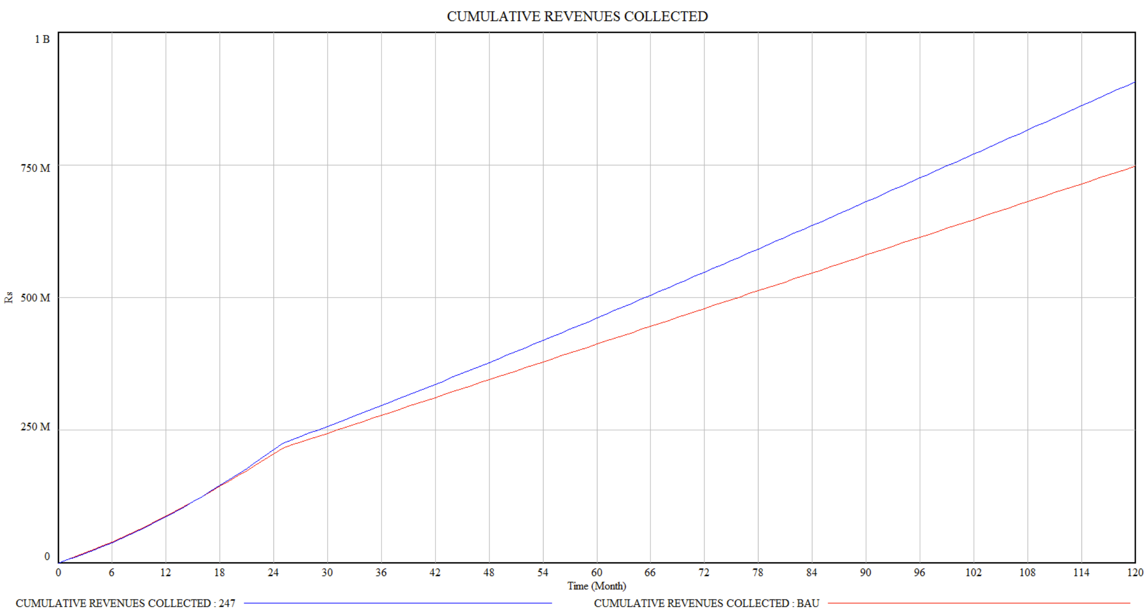

Figure 4. In the 24x7 scenario, Cumulative Revenues are higher, though marginally, as there are more households in the 24x7 Metered stock where charges are almost 4 times higher per litre (a lifeline for poor households has been given at 100 lpcd). The inflection at month 24, changes the trajectory of the revenue curve, as the water in the reservoir been depleted – from that point on, the amount of water supplied (from which revenue is earned) is subject to the inflows to the reservoir from the catchment area and river.

Costs and Benefits

Operational and Maintenance Costs

For each type of water delivery system, the primary costs considered by engineers and government agencies are the costs of setting up and running it, including maintenance and depreciation.

Standard methods and data from Navi Mumbai and for other cities from the literature are used in the model to calculate the basic costs of delivering water, either in the Intermittent system or the 24x7 configuration[15].

[15] These costs (regardless of which distribution system is in place) are estimated to be Rs 0.030/Litre, *www.wsp.org/wsp/sites/wsp.org/files/.../WSP_Karnataka-**water**-supply.pdf*

The benefits to households and communities of having access to water are taken to be the same for all delivery systems.

Coping Costs

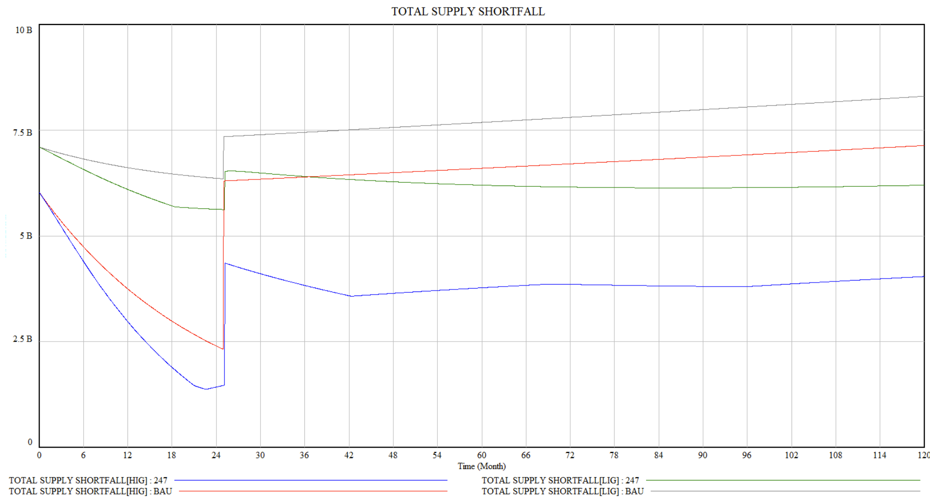

Figure 5: shows the demand-supply shortfall of both income groups in the BAU and 24x7 scenarios; at month 24, the reservoir depletes, suddenly increasing the shortfall across the income groups (there are still significant numbers of households in the intermittent stocks) however with 24x7, the shortfall is still significantly less than the BAU scenario

Whenever there is a gap between demand and supply, households find ways to bridge it by acquiring water from sources other than the municipality, which usually involves considerable additional expenditure.

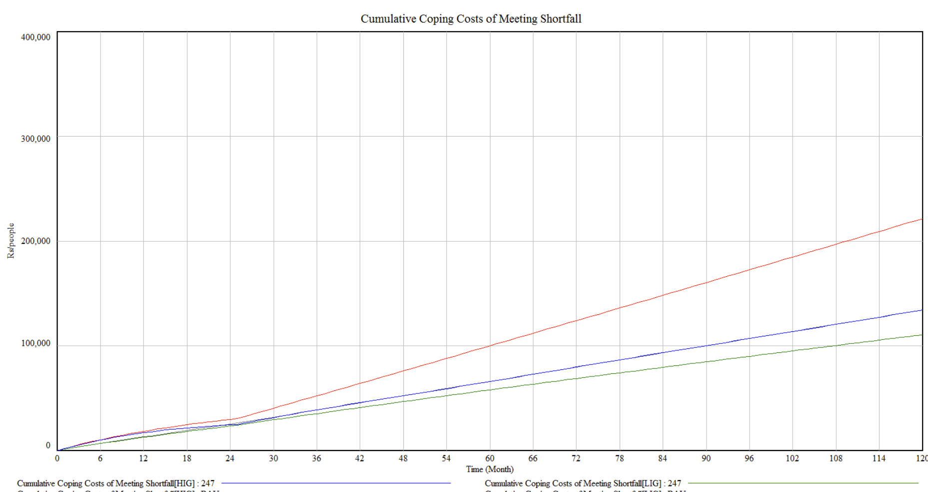

Figure 6. Cumulative coping cost for both HIG and LIG segments reduce with 24x7

For HIG, these "shortfall coping costs" include the payments made for storage tanks, pumps, filtration devices and water purification. Purchasing bottled water is another such cost. These costs come to approximately Rs 0.4/Litre; therefore over the course of the 10-year model run, the 24x7 system saves an HIG individual, over Rs 90,000 (~USD 2000/person). This amounts to roughly five months salary for a typical middle class household.

The story is similar for the LIG segment: adoption of 24x7 results in a cumulative savings of approximately USD 500/person over the model run, amounting to some six months of salary. Coping costs could be reduced significantly, by making sure an optimal mix of households are promoted to 24x7 from the Unmetered and Metered Intermittent households since they are sensitive to the timing of the migration to the new system[16].

Opportunity and External costs

The health costs to the individual and the municipality are also important externalities that must be considered in the model. It is documented that India, Pakistan and other developing countries spend over USD 50/year/person treating water borne diseases; though the data is still under review, 24x7 or similar projects which provide clean potable water have been shown to reduce the incidents of water related diseases in communities.

Opportunity costs, such as those for activities foregone while acquiring the additional water need to be studied more carefully. Currently, the data on this are not sufficient to make a useful sub-model but future studies will need to probe these issues further.

THE SUPPLY SUB-SYSTEM

This model studies the implications of different distribution systems – primarily the old BAU Intermittent System (with or without meters) and the proposed 24x7 Continuous System for delivering water in a city. It assumes that the external supply system (which brings water into the city) remains constant, and undergoes no major structural changes during the period of the model run.

[16] Word of mouth and political effects are at play here as well.

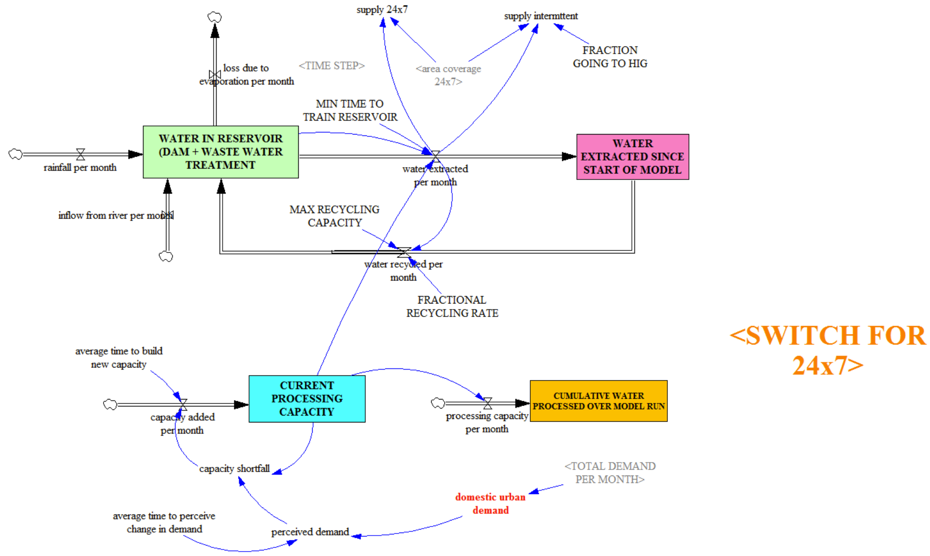

Figure 7. The supply sub-system; water extraction from the reservoir depends on the municipal agencies processing capacity, which in turn is demand driven

In a city such as Navi Mumbai, most of the city's water requirement is met by a nearby reservoir created, by damming a local river for this purpose. The water flows are given in the attached list of assumptions in the supporting documents. The amount of water that is taken from the reservoir each month depends on the processing and storage capability of the municipal corporation, and this in turn is demand driven. The decision to acquire new processing capacity depends on long-term demand expectations and is modeled on the basis of a 5-year moving average of the actual demand. The time delays in implementing such decisions can be several years, typically between two and three.

Starting with an initial processing capacity of 7.8 Billion Litres/Month (=260 Million Litres/Day), in the BAU case, growth of demand due to increases in population is expected to lead to an increase in this capacity to 19.4 BL/M over ten years. With changes in demand due to the introduction of the 24x7 system, however, the capacity needed would be only 16.50 BL/M. The savings in terms of costs and sustainability from not having to acquire additional new processing capacity are significant; in cumulative terms, the amount of water not extracted between the two cases is 160 Billion Litres. The savings from not having to acquire the additional capacity slightly extends the life of the reservoir: if the inflows to the river do not increase over time, the stock of "Water Available", drains out the second year, whereas with 24x7, the same value is reached at a somewhat later time. Basic sensitivity analysis shows that the rate at which the reservoir depletes depends on the population of the city, demand schedules and the fraction of the population living in the low-income groups. By changing these, the city can significantly alter sustainability of its water sources.

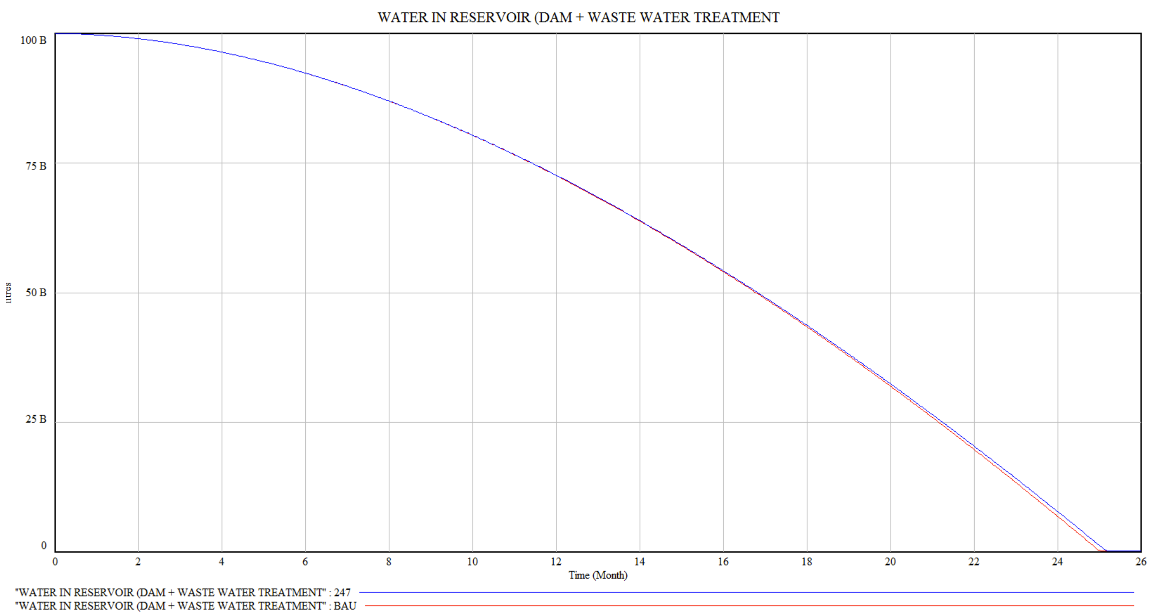

Figure 8. Water available in Reservoir, with the 24x7 scenario, depletion takes slightly longer – this variable is highly sensitive to population and per capita demand.

For the initial runs, the model assumes that all the water withdrawn from the reservoir and treated goes to the city; 24x7 households are given first priority and the remaining water is distributed to the Intermittent system; and within the Intermittent system, 80% of the water is consumed by the HIG and the remaining is available for the LIG households.

Conclusions

Overall Costs and Viability

The capital investment required to set up the 24x7 is substantial; most municipalities undertaking such ventures usually get soft infrastructure loans, repayable over an extended period. A simple calculation shows that if the average investment per household is USD 2000[17], when amortized and compared with household consumption, this results in an additional cost per litre of around Rs 0.012/Litre; in addition, the actual cost of production and supply is about Rs. 0.030/Litre. When multiplied by the cumulative volume of water produced, it is apparent that the 24x7 system, results in significant savings to the municipality, regardless of the fact that the entire system is making a loss because of the political commitment to supply underpriced water to households. Water utilities in India are rarely viable without significant public subsidies and private cross subsidies; however, the case for 24x7 is strong even with this

17 On average, capital and management costs amount to approx. USD 50 million for 25,000 households connected the 24x7 water grid.

simple model - savings of over Rs 6.5 Billion (~USD 170 Million) can be accrued over the course of 10 years.

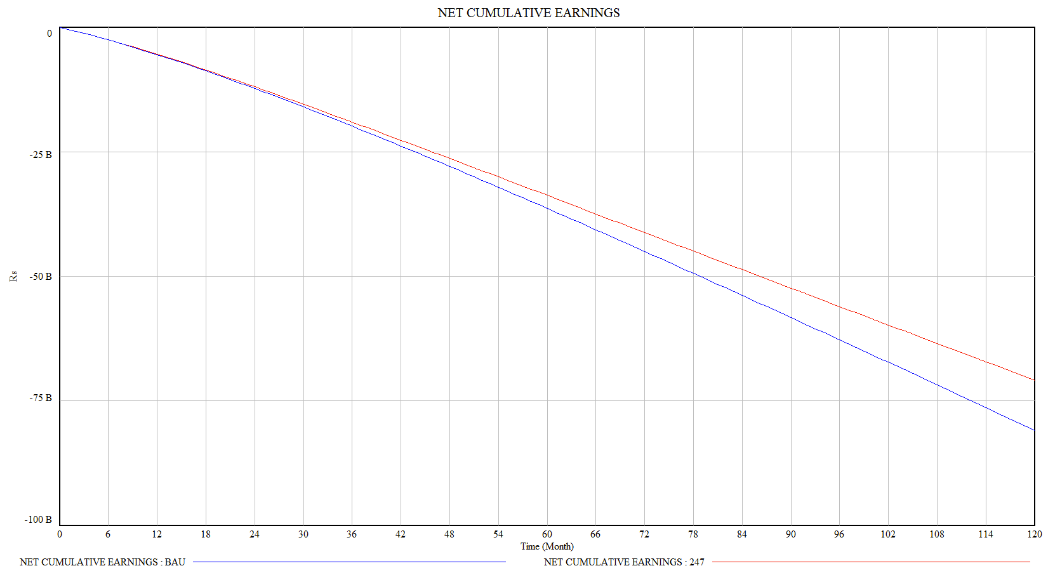

Figure 9. Losses are incurred regardless of which distribution system is used; however with the 24x7 case, there are significant savings over the course of the model run (amounting to USD 160 Million)

As previously demonstrated, the model also shows a small but significant increase in overall revenue, through overall demand reductions in both income segments as compared to the BAU scenario. In terms of equity, the model shows that as households with access to 24x7 water spread, particularly in poor areas, the demand-supply shortfall and coping costs come down significantly.

Furthermore, as overall demand decreases relative to the BAU scenario, the rationale for acquiring additional capacity also gradually disappears, even with a growing population. This in turn reduces the environmental impact on the reservoir.

The model shows that to help bring about a better understanding among the mental models of many different stakeholders that:

- The equity aspects of 24x7 are highlighted, showing that pricing water, can reduce waste, increase availability and greatly reduce coping costs for individuals, particularly the poor. [Important to civil society organisations]
- Even though the capital investments needed are large, cumulative savings are significant and may even pay for themselves, while reducing demand pressures despite a growing population[18] [Important for municipalities]
- 24x7 can have a significant impact on the sustainability of a urban water supply reservoirs [Important for environmentalists]

18 By including externalities related to savings from health costs, the overall savings would be even more dramatic.

Regarding Future Revisions of the Model Would Need to:

- Improve accuracy of “guestimated” parameters in collaboration with engineers, residents in 24x7 communities
- Include Industry and Agriculture Sub-models
- Model external costs, such as health costs of intermittent supply to individual and municipality
- Model opportunity costs, such as loss of time for work or study